Space Weather Technical Forecast

Issued on Sunday, 05 March 2023 at 01:18 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares (R1-R2; Minor-Moderate radio blackouts) likely. Chance of Minor Geomagnetic Storm G1 intervals. Active Electron fluence forecast.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been at Moderate levels over the past 24 hours, with three M-class flares observed by GOES16 and peaking at M5.2 at 04/1557UTC,from sunspot region AR3234 close to the northwest limb. This initiated a significant Coronal Mass Ejection (CME). AR3234 has now rotated off the visible disk. Eight numbered sunspot regions feature on the disc, with AR3234 having rotated across the northwest limb. AR3242 in the northeast is the largest region with further development of the forward portion and maintains beta-gamma magnetic configuration. AR3243 in the northwest continues to evolve with a north-south orientation and development of further umbra. AR3244 in the southwest has shown some spot emergence. Most of the remaining regions are unchanged unipolar and appear inactive. At present there are thought to be no significant Earth-directed CMEs, however this is discussed further below.

Solar Wind / Geomagnetic Activity: The solar wind as observed at L1 by DSCOVR and ACE, has been firmly connected to a negative polarity high speed stream (HSS), with the phi angle accordingly negative (towards the Sun) throughout. The source of this activity associated with the large and equatorial CH81/-. The solar wind has been at elevated to strong levels and is currently assessed around 600km/s. The solar wind density was below average in low single-figures ppcc. The IMF was relatively smooth in character, reaching a peak of just under 8nT at 04/0421UTC with weak levels observed. The north-south component, Bz, varied between +/-7nT, with a predominantly anti-aligned bias with Earth's field. The net effect of the above solar wind measures was for Quiet to Active geomagnetic activity (Kp2-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at Background levels. Electron flux at GOES16 has been moderate to high with a peak of 1700pfu at 04/1625 UTC. Electron fluence was just below the Active threshold (1e8 integrated flux), with an upward trend observed and a value of 8.97e7 integrated pfu recorded at 05/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity has been Moderate with three M-class flares observed in the past 24 hours, the largest being M5.3 at 04/1557UTC from AR3234 on the northwest limb horizon. Also observed was a M1.1 flare likely from developing AR3243 at 04/0710UTC and a M1.2 flare at 04/1342UTC from AR3242. Though AR3234 has now rotated over the limb the flare risk remains elevated, particularly as new regions rotate further into view. Further M-class flares are likely with a slight (10%) chance of another isolated X-class flare.

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Solar Wind / Geomagnetic Activity: No significant Earth-directed CMEs feature in the current forecast, however there is a low risk of a glancing blow from the fast CME associated with the X2.1 flare 03/1752 UTC, which could possibly arrive early on Day 2 (6th). A further CME was observed from the M5.3 flare and this may glance Earth of Day 4 (8th). Both flares mostly headed westwards from the sun. The current geomagnetic forecast is dominated by the HSS related to CH81- which only looks to wane later into Day 2 (6th) or more likely Day 3 (7th). A chance of G1 Minor Geomagnetic Storms throughout, with the risk probably more heightened on Days 2 and 4 (6th and 8th) due to the possible arrival of the aforementioned CMEs glancing blows.

Energetic Particles / Solar Radiation: Although High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels, recent flare activity implies there remains a slight chance of protons increasing in the immediate term, reverting to the raw risk for the disc at nearer 5 to 10% into the new working week. Electron flux is likely to continue at moderate to high levels perhaps becoming suppressed at times given any further active geomagnetic activity. Electron fluence is forecast to breach the active threshold through Day 1 (5th) and potentially rising a little further and remaining above active levels through the guidance period, although the potential for more significant geomagnetic activity, especially for Days 2 and 4 (6th and 8th) leads to a lowering of confidence.

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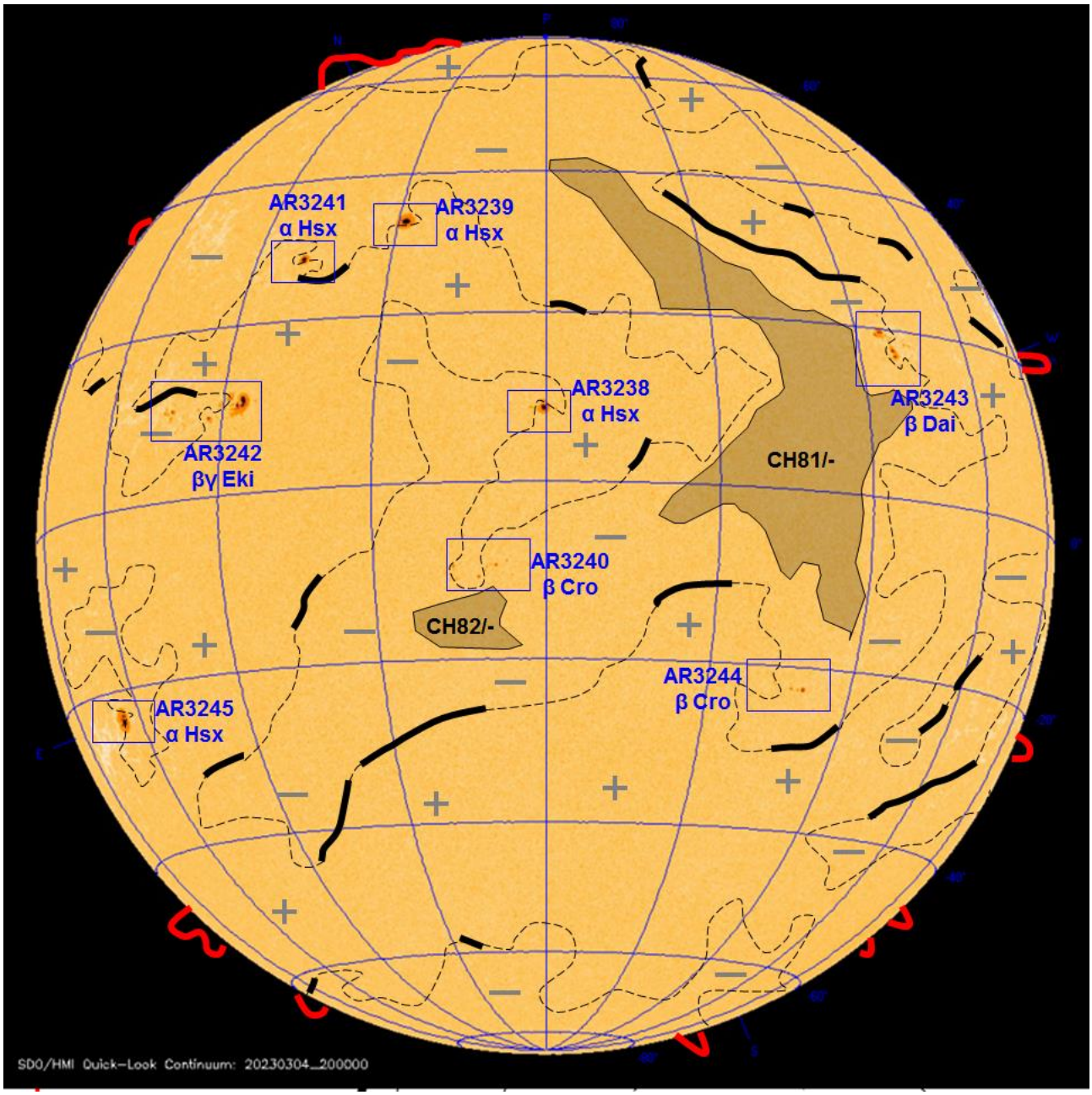
Figure 1. Solar Analysis Valid 2000UTC, 4 March 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No significant Earth-directed CMEs feature in the current forecast. However there is a low risk of glancing blows from the CMEs associated with the X2.1 flare on 03/1752 UTC, and the M5.3 flare on 04/1557UTC, which Met Office ENLIL ensemble forecasts are signaling could possibly arrive during Days 2 and 4 (6th and 8th).
The current geomagnetic forecast is dominated by the HSS related to CH81- which only looks to wane later into Day 2 (6th) or more likely Day 3 (7th). Earth is currently very close to the March equinox, and as such negative polarity features ought to be maximally potent. Earth does in fact reach its maximum southward limit with respect to the solar equator towards the end of this four-day forecast, before undergoing a gradual six-month journey back northwards. On last pass the analogous feature to CH81- gave a protracted spell of Active and then Unsettled Kp, with a relatively higher risk of reaching G1 expected on this pass, probably front-loaded to the main and most intense portion of the coronal hole which looks to peak overnight into Day 1 (5th) based on ENLIL output, but lower confidence resulting in a smooth partitioning of this risk between UTC days. Strong solar winds probably only slowly waning from Day 1 (5th) onwards. Overall a chance of G1 Minor Storms throughout, with the risk on Days 2 and 4 (6th and 8th) more associated with the possible arrival of the aforementioned CMEs glancing blows

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	10	30	20	30
Strong	G3	No	1	5	1	5
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
03/2256	Partial	AR3234	NW	802	06/0900 UTC	Glancing blow possible, but most material observed to west of solar disc

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Radio Blackouts - X-Ray Flares:
AR3234 has now rotated off the visible disk, having produced the X-class flare (X2.1 at 03/1752UTC) as well as the M-class flare in the past 24 hours. It is no longer possible to definitively identify any changes to size or classification/ Delta spot(s), however it is suspected to persist as a complex and active area in light of recent flares and as such it continues to contribute to the flare risk into Day 1 (5th). Eight numbered sunspot regions feature on the disc, with AR3234 having rotated across the northwest limb. AR3242 in the northeast is the largest region with further development of the forward portion and maintains beta-gamma magnetic configuration. AR3243 in the northwest continues to evolve with a north-south orientation and development of further umbra. AR3244 in the southwest has shown some spot emergence. Most of the remaining regions are unchanged unipolar and appear inactive. Far side data does suggest multiple sunspot regions massing behind the eastern limb with a steady stream looking to emerge onto the visible disk during this forthcoming guidance period. Their contribution to any risk increase into the coming new UTC week is not assured but for now helps to elevate risk values into Days 3 and 4 (7th and 8th). Moderate solar activity is likely to continue with further M-class flares and a slight but reducing chance of isolated X-class flares giving High solar activity.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	40	50	60
Very Active	R3 to R5 X Class	No	10	5	5	10

Figure 2: X-ray flux plot at GEO showing several M-class flares observed in past 2 4hours.

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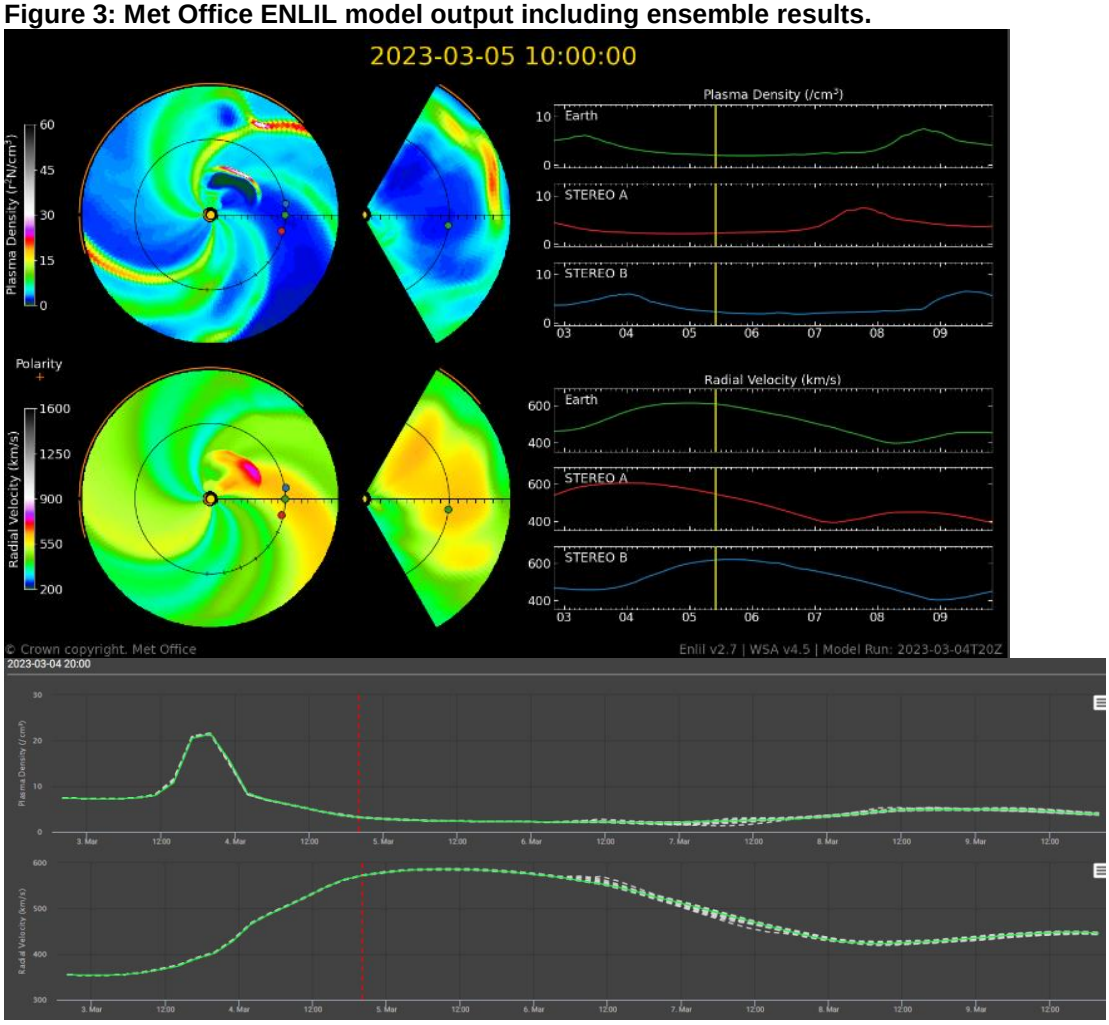
Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. Although S1 radiation storms have not been observed given recent flare activity implies there remains a slightly increased chance of protons increasing in the immediate term, reverting to the raw risk for the disc at nearer 5% into the new working week. Dominating this risk remains AR3234, which will continue to present a gradually fading risk as the region rotates off behind the western limb. While yet to appear, the numerous arriving eastern hemisphere spots due in the period should not appreciably contribute to the risk of S1 or greater until later next week.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	5	5
Very Active	**≥ S3 ***	No	5	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: Met Office ENLIL model output including ensemble results.



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High Energy Electrons Event (≥ 2MeV):
Electron flux is forecast to continue at moderate to high levels perhaps becoming suppressed given any more active geomagnetic activity, however more protracted periods of High levels are eventually expected given current HSS, with this most likely to occur into Day 3 (7th). Electron fluence is forecast to breach the active threshold through Day 1 (5th) and potentially rising a little further and remaining above active levels through the guidance period, although the potential for more significant geomagnetic activity, especially for Days 2 and 4 (6th and 8th) leads to a lowering of confidence.

MOSWOC REFM output displays a mostly flat lining forecast for the next couple of days, close to the active level which is accepted though the potential for geomagnetic activity through Days 2 and 3 (5th and 6th) mean lower confidence. Persistence gives a more forceful upwards trend for Days 3 and 4 (7th and 8th) and this is tentatively accepted as a guidance outcome for this period with moderate confidence at best, and probabilities in the table above have been raised to 5% for the 1e9 threshold to be reached.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	80	90	80	70
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	5	5

Figure 4: High energy electrons at GEO and Met Office REFM output.

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